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Original Article

Smart Enclosures with Smart IO/Technologies; Cost Effective, Flexible & Maintenance Friendly

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Abstract *- Global economy is facing a recession, and there is wide fluctuation in energy demand. This fact is forcing the projects to become more cost competitive while reducing the project schedule. Projects in Oil & Gas sectors have increased dramatically in scale and complexity, whereas there is hardly any additional time allocated to complete these projects. Automation hardware & software has come under more pressure due to the dependency on design data from other disciplines. With increased complexity, input data continue to change throughout the project design cycle. Addressing these concerns has become a major challenge for control system design engineers. This is where the Smart enclosures, in combination with the new IO technologies like foundation fieldbus, remote IO, smart IOs etc., become handy to control system engineers. The automation industry has evolved itself and is continuously upgrading the systems to mitigate the cost, allocate design bandwidth along with the management of last-minute changes. This paper will mainly discuss about the various issues and concerns faced by control system design engineers. It will mainly focus on how smart enclosures with smart IO/new technology provides a cost-effective solution, flexibility and ease of maintenance while also addressing the main challenges discussed above. The paper will briefly discuss the main problems faced during various faces of the project and how smart enclosures with new technologies address each of these issues. This paper will also analyze examples of how these advancements help in reducing the footprint, cost & schedules. The authors will also provide the details of the available options in the market and will share their experience on the projects using the smart enclosures and how it addressed the typical problems faced during the project life cycle.*

Keywords *- Smart IO, Smart enclosure, Universal IO, Smart wiring, System design, Remote IO.*

1. Introduction

Some of the most challenging aspects for any design engineer are cost optimization and absorbing the design changes in every project phase without impacting the project schedule. These challenges are being addressed effectively by advancing technology and modularization in control systems, making the overall control system packages evolve and speedily.

In recent years, control systems not only possess the stability of traditional control systems and the digital characteristics of fieldbus control systems but are also furnished with features such as “universalization” and “standardization,” thereby making control systems even smarter. A new generation of control systems built upon new technologies, including Foundation Fieldbus, Universal Input/Output module, Smart Marshalling Cabinet, and Smart Junction Box, further enable control systems to take on such complex tasks through intelligent operations, including new functions such as automatic instrument configuring & launch, and automatic loop testing. At the same time, these control systems make things simple by standardising complex signal modules into universal ones, thereby achieving various goals, including an effective cost reduction of total plant construction cost, reducing construction time, universalizing hardware, and standardizing spare parts.

2. Detailed Analysis

2.1. Main Challenges of the System Design Engineering

There are many concerns & challenges for Automation design engineers. However, this paper will focus mainly on the issues faced by Automation/Systems related issues. Following are some of the basic but most challenging concerns:

2.1.1. Optimization

Space

Plant interface buildings, field auxiliary rooms, control rooms, or any rack rooms are always short of space towards the engineering completion time. Hence optimizing the space in these buildings is always a concern. With the modularization concept gaining more and more acceptance, the rack rooms are required to be as small as possible. Reduction in rack room size also impacts the cost indirectly, so this continues to be a priority on every project.

Schedule

The project schedule is always critical. The EPC project cycle is already being stretched to a margin, and various reasons are causing delays within this already optimized schedule causing further concerns. The main reasons for these delays are:

- Delay in enabling input data from other disciplines (e.g., input process or from mechanical packages)
- Vendor input delays
- Addition of new IOs.
- Design Change Request from Client

All of the above also impacts the cost escalation of the project.

2.1.2. Last-Minute Design Changes

All design engineers will agree with the fact that despite all precautions, there are still many changes in the design after the initial freeze of the no. of IOs as well as the type of IOs. While complexity in the design is one of the major reasons, there can be changes due to late design development, misunderstanding of FEED data, additional controls requirements generated by HAZOP review, SIL review or due to company/Licensor late reviews, late input from a mechanical package vendor.

2.2. Main Options to Mitigate the Above Concerns

2.2.1. Smart Technologies

Major communication technologies available in the industry are HART, FF (Foundation Field bus) and wireless technology.

HART is the most widespread and trusted technology by almost all industry leaders. It's a hybrid analog & digital industrial automation protocol as it can communicate over legacy 4–20 mA analog instrumentation current loops, sharing the pair of wires used by the analog-only host systems. Due to the huge acceptance of 4–20 mA systems throughout the world, the HART Protocol is one of the most popular industrial protocols today.

Foundation fieldbus is an open, integrated total architecture for information integration. Foundation fieldbus is an all-digital, serial, two-way communication system. FF(H1) interconnects "field" equipment such as sensors, actuators, and other I/O. High-Speed Ethernet(HSE) provides integration of high-speed controllers, H1 subsystems (via a linking device), data servers and workstations. Foundation fieldbus is the only protocol with the built-in capability to distribute the control application across the network.

Wireless device networks have recently emerged as a new technology in the process automation market. Initially, wireless technology offered a way to monitor measurement that previously had been too costly to bring into the Process Control System. Wireless adoption is increasing and offers tremendous cost savings potential for installations worldwide, and it is no longer used only for monitoring but also finding its way into control applications.

Smart IOs

IO's are the most significant aspect of System engineering design in terms of sizing of controllers and hence indirectly affect the most significant system-related aspects of any project, which are space, schedule & cost. Even last minutes changes are addressed very effectively by the use of smart IOs

Smart I/O works on I/O on Demand concept. It allows the end-user to have what type of I/O they want when they want it, wherever they want it, or, more simply—I/O of any type, anytime, anywhere.

The Smart Enclosures in process control applications are cost-effective in any scenario over conventional marshalling systems.

How does Smart IO work?

This technology allows any type of field signal (wiring) to be connected to any terminal. The cable landing in terminals is irrespective of IO Type (AI, AO, DI, DO, RTD etc.) or any sequence. When the signal is connected to the IO card, this channel is ready to marshal in any controller of DCS, which means we can save cross-wiring or marshalling cabinet and have more flexibility to adopt the future changes in IO type. A digital Connection is established between the IO card and the controller. Any change of field device after installation can be catered to either by software change or by replacing the single card.

SMART IO can be software-based, in which multichannel IO cards can be configured by software.

Smart Enclosures

With all the technologies mentioned above, where does Smart enclosure fit? Will Smart enclosure displace bus technologies or wireless technology? Each technology will have its ideal applications depending on different situations and customer preferences. For example, if a customer is well-versed in Foundation Fieldbus and is doing an expansion, Foundation Fieldbus is probably the way to go. On the other hand, if a customer has no experience with Foundation Fieldbus and still wants to maximize hard-wired IOs, then Smart enclosure is a better solution that will offer similar benefits. The extent of benefits will vary depending upon the adaptation of the various options available.

2.3. Smart Enclosures with New Technologies and Smart IOs are the way forward

Authors have experienced from recent projects that Clients are adopting new technologies with various

combinations depending upon the cost/schedule pressure and the value/flexibility each combination gives.

To understand the conventional and smart IO, Refer to the following example with Figure 4,5,6,7 at the end of the paper.

Authors have used the above combinations on various projects and found that using different options gives tremendous flexibility & cost reduction during the engineering phase while helping in faster commissioning and easy maintenance. The authors also realized that the cost of smart IOs is more than the conventional; however, the cost of cable reduction is so huge that it still reduces the overall cost significantly with the advantage of added flexibility. Authors recommend a careful review at the time of estimate as cable cost is often considered for reduction while some engineers do not factor in higher hardware costs. Authors also experienced high acceptability and willingness by end-users for the foundation fieldbus, even for critical control loops. In one of the recent projects, the specifications asked for principal approval for not using foundation fieldbus for process control applications. Using these combinations, authors experienced an approximate 30% cost on the projects. However, the Authors do feel that there is a higher potential of approximately 40%+ cost reduction in future. This will be since the production of smart IOs will increase, and the volumes will be higher due to higher acceptability in the industry. Authors also experienced a faster turnover of FF loops than HART loops at the site. Smart IOs with non-FF loops also give tremendous benefits during commissioning. This is since every project change, or addition in IOs is required during commissioning, specifically on the vendor packages where the vendor does the field design while the MAC design is done by DEC (Detailed Engineering Contractor).

3. Available Solutions in the Market with the Emerging Concept of Smart Enclosures

One is the Emerson way which they call CHARMS (Characteristic modules); here, every field device has its own corresponding characteristic module, which can be fixed at any channel. All different charms can sit on the same slot, which means you can change the IO type by simply changing the charm as you move on with engineering changes at any time of the project. This means it becomes a 96-channel universal IO module for all practical requirements & any channel can be used for any type of IO device by simply replacing the charms type. Output from the module is ethernet, so a single fiber optic cable can take the data to the controller, which means you can also keep this in the field near your devices so you can run the cables directly to the field and from the field, you can have FO cable only.

Fig. 1 Characteristic modules (CHARMS)

Another one is still more flexible, like Honeywell or Foxboro universal IO module; here, any channel on any module can be configured for any type of IO. This is all configurable through software which means you can take any wiring to any place & then simply configure the channel to a suitable IO type. All you need to do for any late changes on the field side is change the configuration to the new IO type without any physical change in the field or control room wiring.

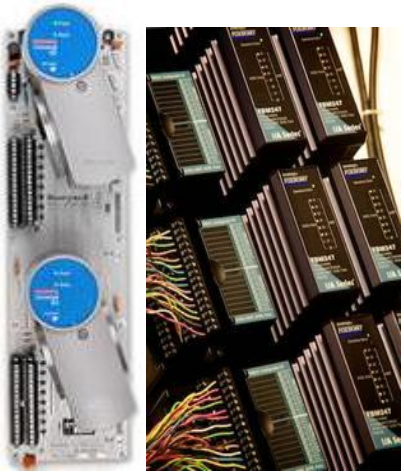

Fig. 2 Universal IO module

3.1. Emerging Concept of Smart JB/ Intelligent Enclosure

With increased user demand, digital intelligence modules are further expanded from the central control room to all corners of the field. When UI/O modules and communication modules are further integrated into a traditional field junction box (JB), it becomes a smart junction box (SJB). It comes with a standard, off-the-shelf, pre-engineered enclosure ideal for applications requiring modular, cost-effective distributed I/O.

A conventional junction box is connected with DCS by using home-run cables. A smart junction box can be installed in the field, and SMART IO modules are inside the junction box. Signal communication from a smart junction Box to DCS can be done by Ethernet or Fiber optical cable, which is cheaper than multicore cable.

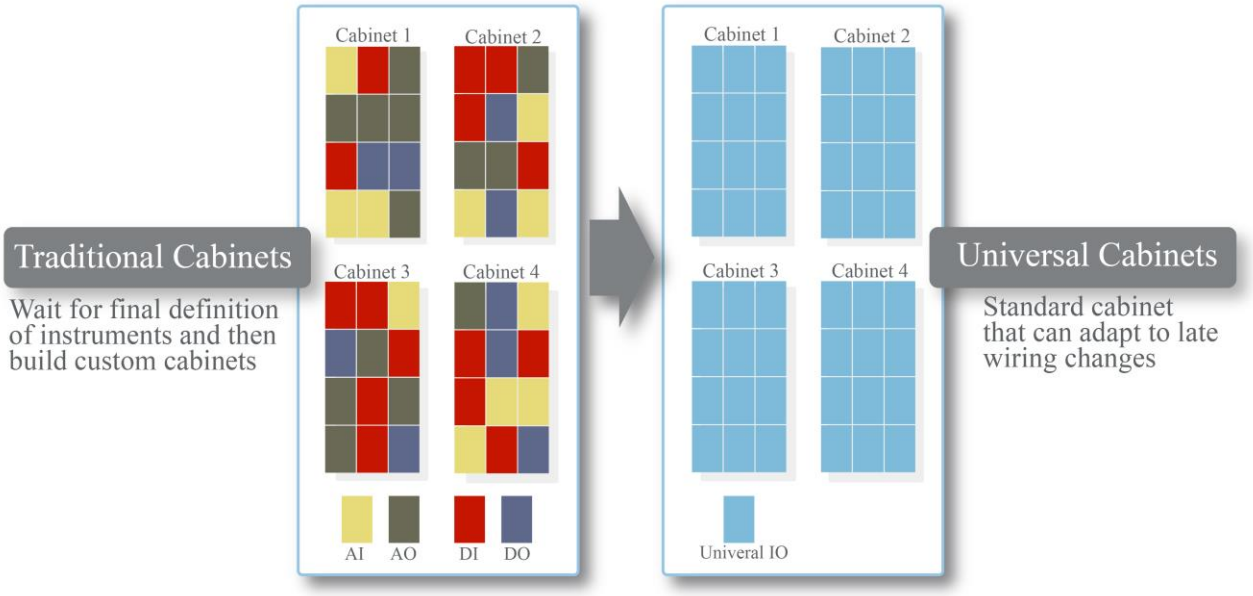

Fig. 3 Traditional vs Universal Cabinet Design

Using Smart Junction box project cost can be reduced in terms of cable quantity documentation, execution time and engineering hours. Also, there is a huge cost saving with the elimination of marshalling cabinets, thus eliminating all associated design and craft labor efforts, reduced field and maintenance labor costs, decreased inventory and cost of spares, less engineering work and less documentation to maintain.

4. Benefits

- SMART IO allows any single I/O channel to be changed at any time during a project and provides flexibility to add or change I/O types whenever there are project design changes, no matter where the I/O is located. This reduces project costs and, even more importantly, reduces startup time.
- It removes the requirement of the cross-wiring cabinet, termination drawing, and termination of multi-paired
- homerun cable was eliminated. Home run cable, cable laying, and cable conduit can be eliminated using Ethernet cable or optical cable from the SMART Junction Box to the DCS cabinet, reducing the project's overall cost.
- It reduces the requirement of Hardware FAT for standardized cabinets.
- With the elimination of cross-wiring and marshaling cabinets inside the CCR, the size of the building gets reduced.
- Less engineering work and less documentation to maintain.
- Decreased inventory and cost of spares.
- Reduced field and maintenance labor costs.
- Break schedule dependencies between mechanical system design/procurement and control system work.

5. Conclusion

Smart Enclosures with New Technologies provides flexibility to design different combinations per the project specifications and Client preference. These combinations allow engineers to choose the optimal design combination to suit the project requirements.

Smart enclosures with smart IOs provide cost & schedule advantages over conventional enclosures/IOs. The percentage cost differential may vary from project to project depending on the project specifications and the client's acceptance of the various combination options.

The above solutions do reduce cable costs significantly. However, there is a slight increment in cost on the system side while the complexity for old system-experienced engineers increases. Hence the cost advantage shall be evaluated carefully by end users.

Smart IO makes the system truly modular as the IOs become universal and configurable. Late design change doesn’t impact the construction schedule. Buffer IO design for late design changes can be either eliminated or reduced drastically as IOs become configurable and new enclosure or IO is very cost-effective, being universal.

The number of spare requirements reduces drastically, IOs being universal. Otherwise, each type requires a separate spare. This also reduces the spare inventory by the end user, drastically reducing the operational cost.

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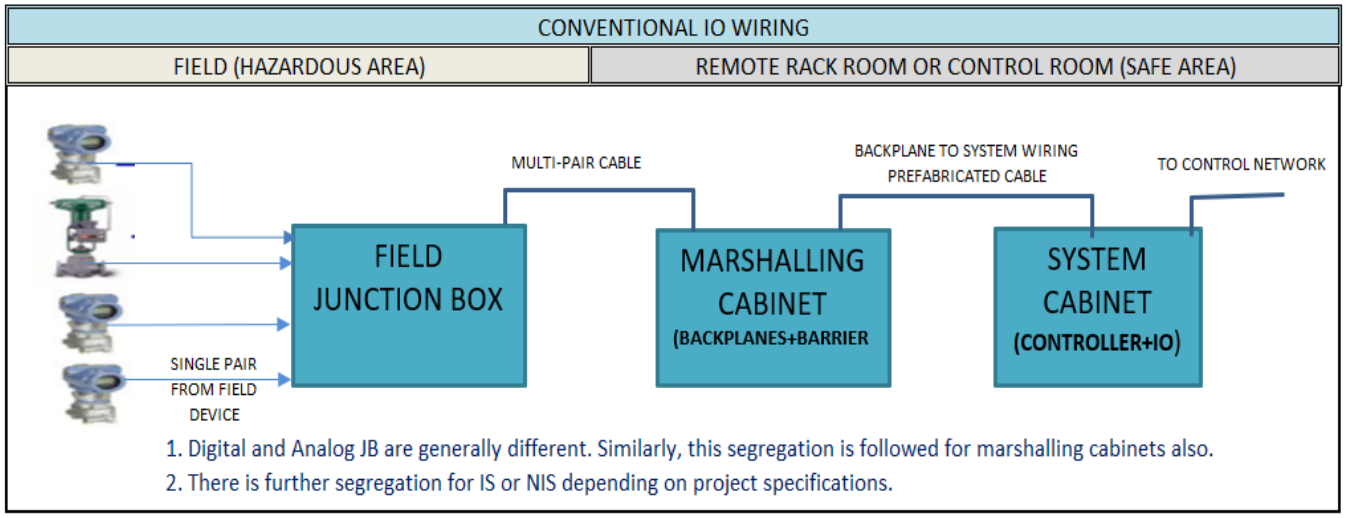

Fig. 4 Conventional IO wiring

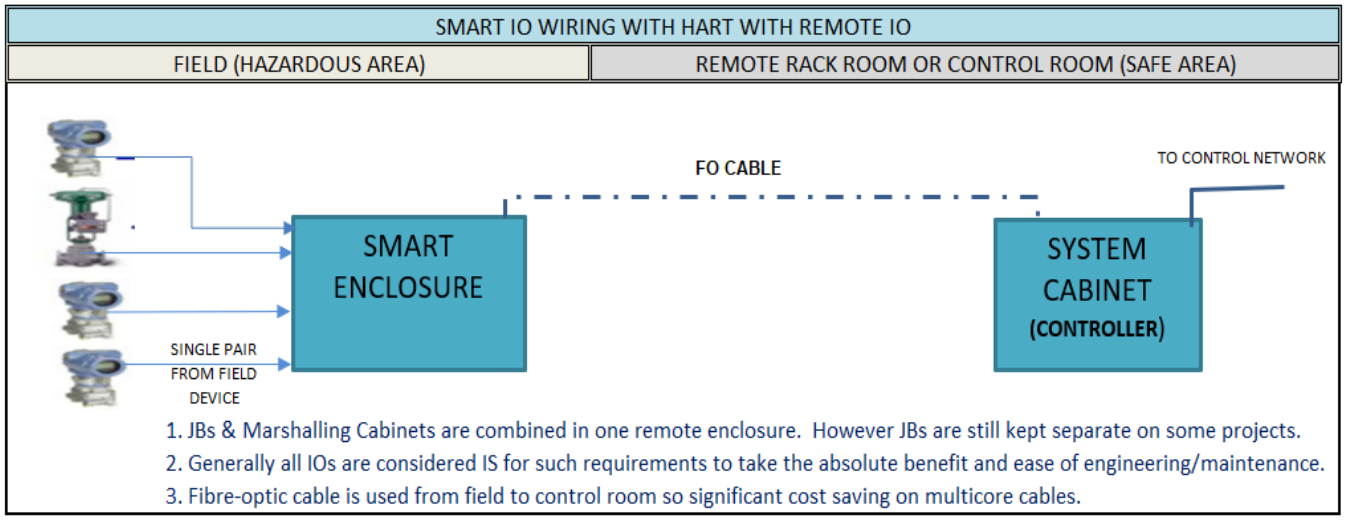

Fig. 5 Smart IO wiring with HART & remote IO

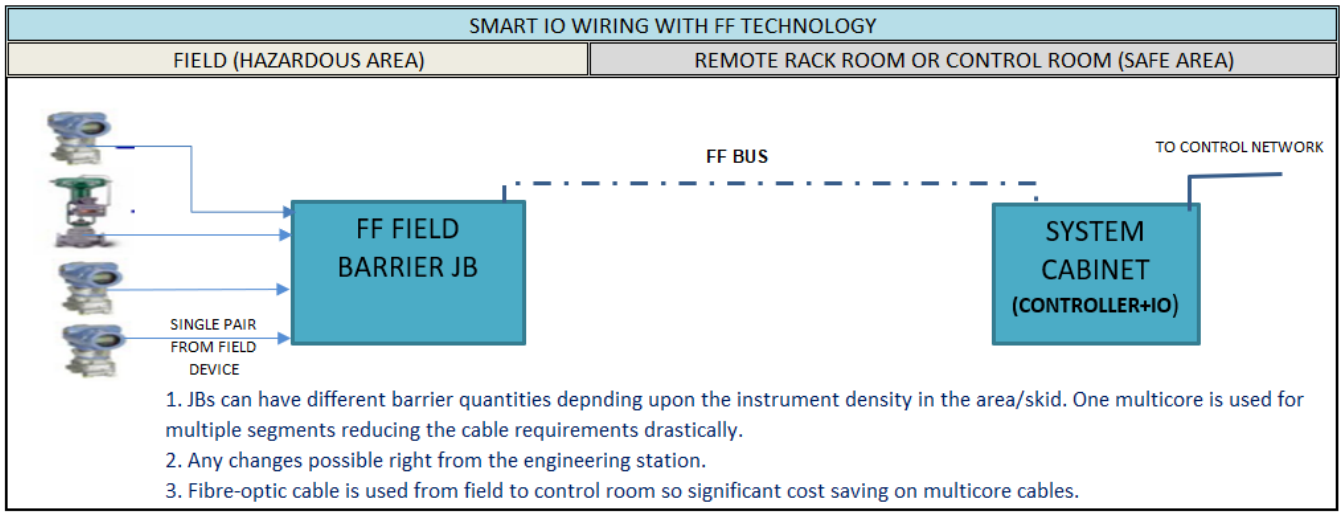

Fig. 6 Smart IO wiring with FF Technology

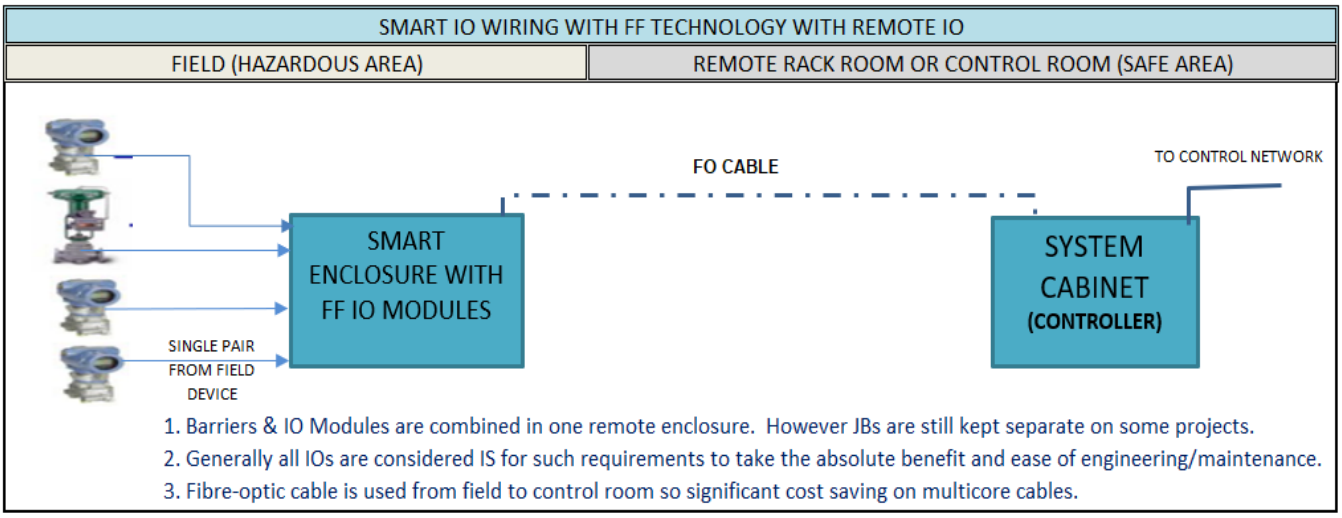

Fig. 7 Smart IO wiring with FF Technology & with Remote IO